Stream Gaging Workshop February 2021

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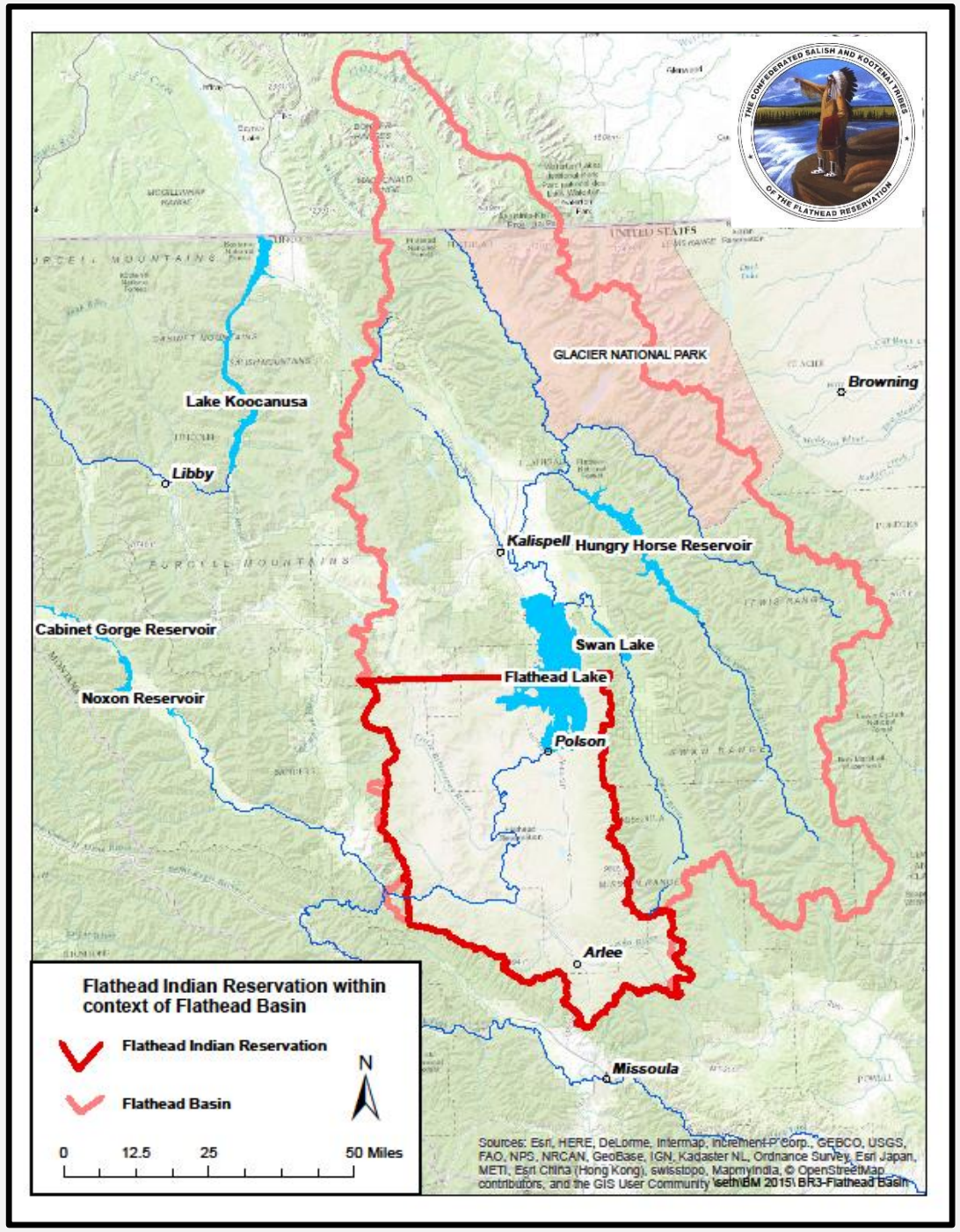
Overview

- **Introduction – Team Effort / Many People / Many Years**
- **Setting – Physical and Social**
- **Big Picture – Why CSKT has invested in Water Measurement**
- **Water Measurement Activities 1906 – Present**
- **Where is the Program headed from here**

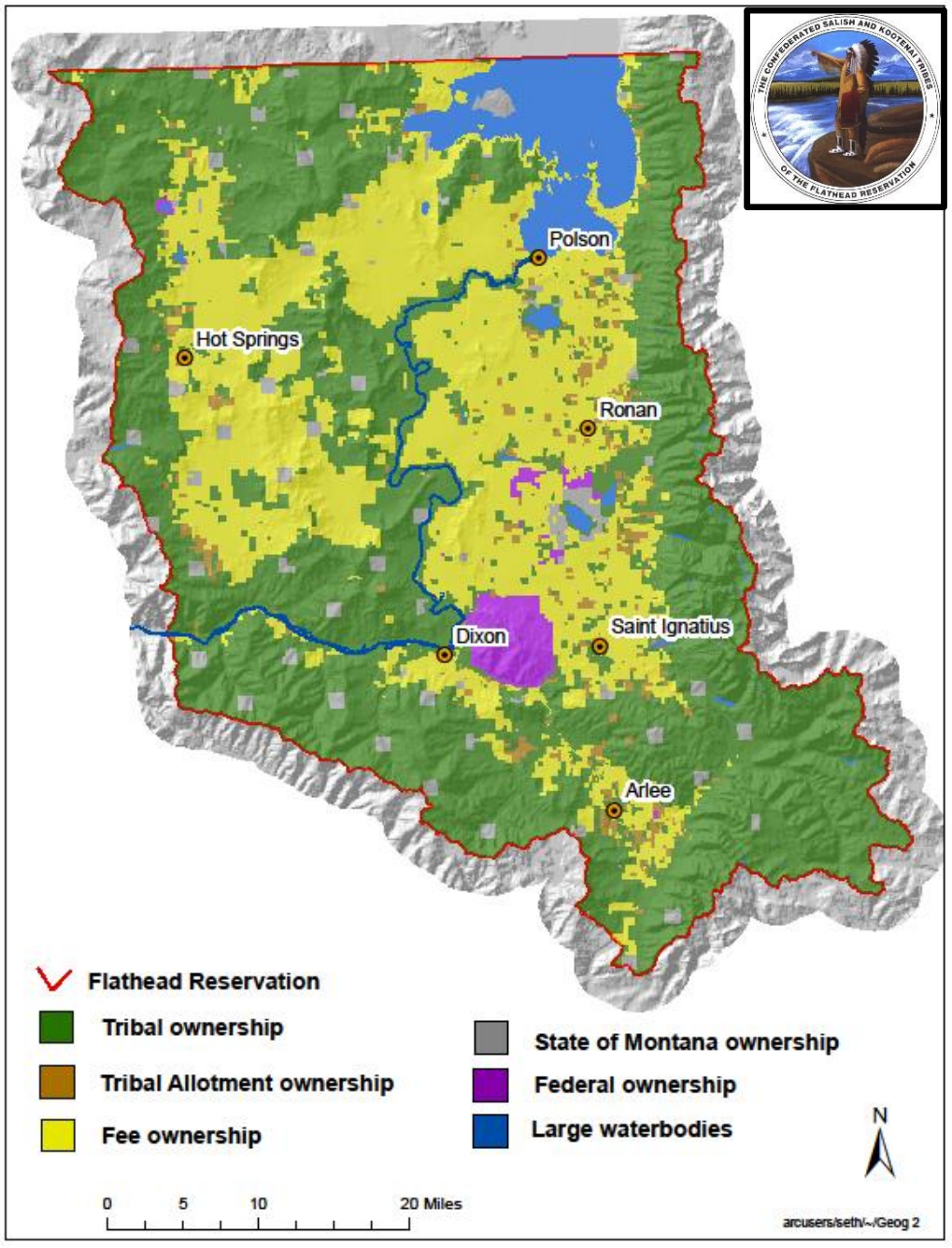


Flathead Watershed and Flathead Indian Reservation

Flathead trans-boundary watershed: British Columbia, Montana, Flathead Indian Reservation

Lower 73 miles of Flathead River flow on Flathead Indian Reservation

8,975 square mile drainage area upstream of confluence with Clark Fork River



Land Ownership Status

Checkerboard Reservation *(2019 land status)*

Flathead Reservation 1.317 million acres

Tribal ownership 842,217 acres
64% of Reservation

Fee ownership 415,440 acres
31.5% of Reservation

State of Montana ownership 36,942 acres
2.8% of Reservation

Federal ownership 22,983 acres
1.7% of Reservation




Highly diverse Reservation – precipitation ranges from ~ 100 inches/year to ~ 10 inches/year

~ 150,000 total irrigated acres > 200,000 commercial forest acres



Water Measurement over Time: USGS Program 1906 - 1918

Objective - Measure several natural flow locations to characterize water availability for developing federal irrigation project

Data has substantial value

- Quality-assured with metadata about locations
- Data coincident with 1908 flood of record
- Extends window for trends analysis

Value added information – comparative hydraulic geometry - used to inform recent restoration designs

	Area		Width		Mean depth		Velocity		Width/depth ratio	
Discharge	Historic USGS	CSKT	Historic USGS	CSKT	Historic USGS	CSKT	Historic USGS	CSKT	Historic USGS	CSKT
100 cfs	59.2 ft^2	50.7 ft^2	45.1 ft	58.1 ft	1.01 ft	0.92 ft	1.64 fps	1.72 fps	45	63
500 cfs	136.7 ft^2	133.2 ft^2	47.5 ft	73.9 ft	2.6 ft	1.8 ft	3.97 fps	4.04 fps	18	41
1000 cfs	196.1 ft^2	201.9 ft^2	48.6 ft	82 ft	3.85 ft	2.38 ft	5.81 fps	5.84 fps	13	34

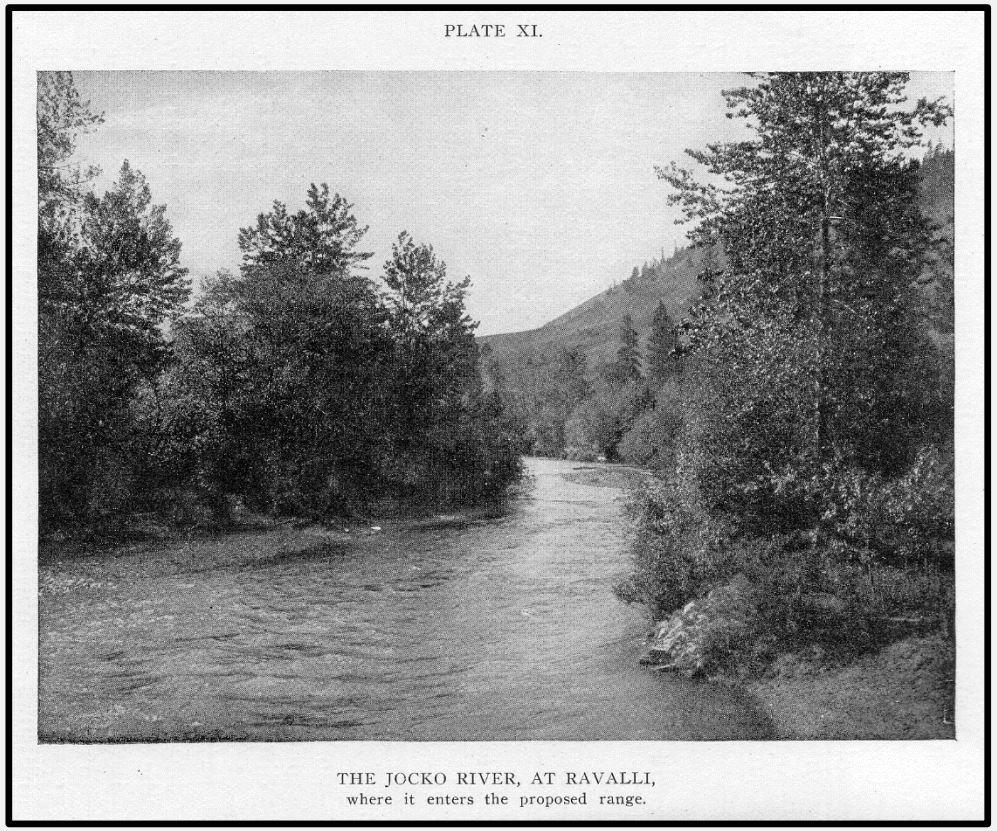


PLATE XI.

THE JOCKO RIVER, AT RAVALLI,
where it enters the proposed range.

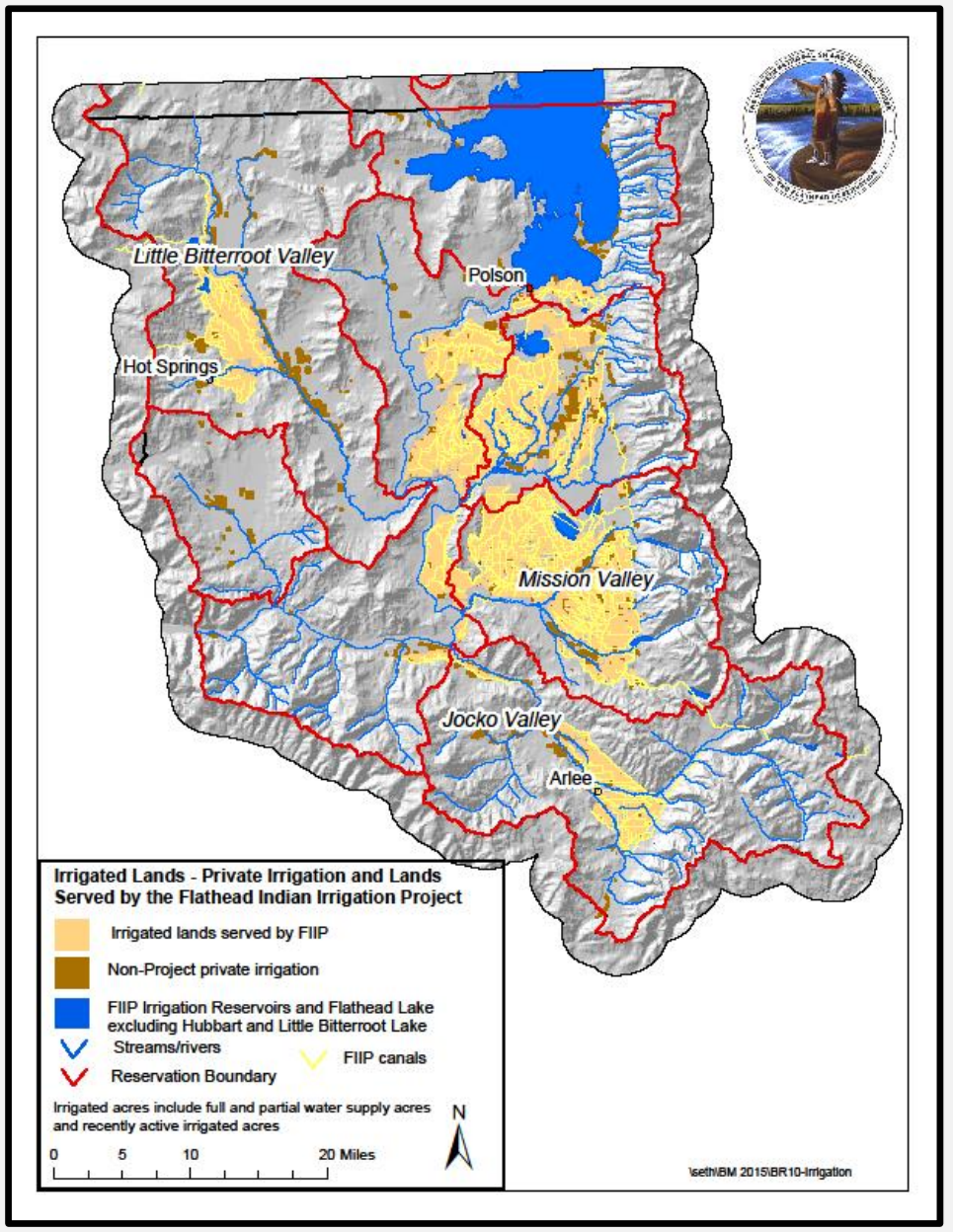
Jocko River gage location 1907

Water Measurement over Time: Federal Irrigation Project 1940's – 1960's

Objectives - Measure natural flow locations for water supply forecasting and reservoir management;
Measure canals for irrigation operations;
Measure on-farm use for irrigation water allocation

Issues – Paper records, very difficult to track records from field to office work-up
Difficult to track quality assurance or review process
Substantial challenge to restore paper record into digital format

Legacy irrigation measurement infrastructure



Water Measurement over Time: CSKT 1982 - 1992

Big Picture Objectives -

- Develop organizational learning - process / capabilities
- Tribal management of Tribal resources on Reservation
- Initiate technical work for water rights adjudication

Technical Objectives - Develop natural flows, often termed virgin flows, across the Reservation stream network to support water rights effort

Approach

Continuous USGS Gages at representative locations

Instantaneous CSKT gages at a large number of streams

Develop large geomorphic / channel geometry dataset

Develop large basin characteristics dataset

Several Outcomes

Highly trained Hydrographer Crew

Data Collection and Data Management Procedures "embedded" in Program

Large streamflow / Geomorphic dataset

Natural flows statistically extended to 50-year 1936 – 1986 base period

Water Measurement over Time - CSKT 1982 – 1992

Data Management – Database

Early on (1983), database programmed in Fortran 77

- **Unique location identifiers – carries through to today**
- **Rating curve tool based on defining straight line segments and applying least squares linear regression to each segment**
- **Rating tables and gage heights populate rated discharge fields**
- **Data integrity has been maintained through 2 database migrations**

Data Management – "Metadata"

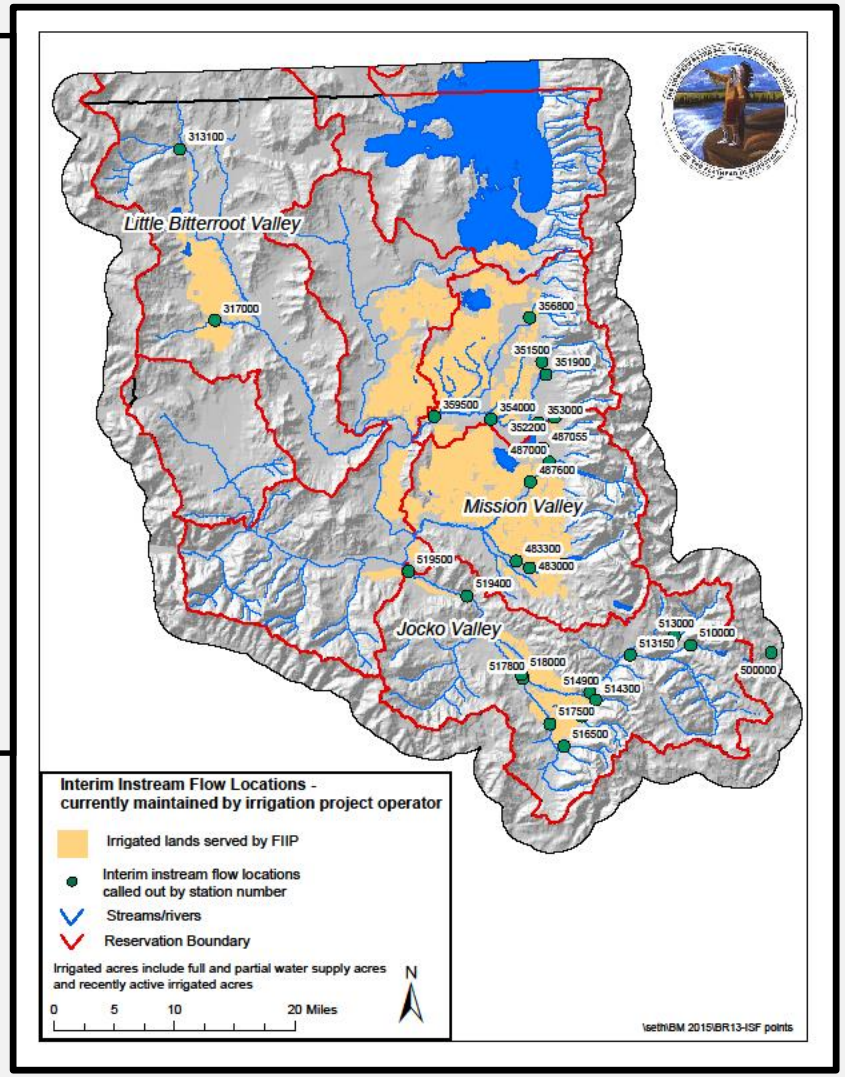
- **Station Description – prepared upon establishment of station and with changes to equipment, location, …**
- **Station Analysis – Annual summary of station conditions. Shifts/Datum corrections, …**
- **Rating Curves**
- **Discharge Notes and USGS 207 Forms**
- **Level Summaries**
- ***Legacy Paper Record was recently scanned and is maintained in searchable Open Text Database***

Water Measurement over Time - CSKT 1992 - 2014

Transition from Instantaneous Measurement to Continuous Recorders
At peak 85 recorder locations – 45 canal locations, 40 stream locations

Shift in Technical Objectives toward Water Management from Water Resources Evaluation

- Greater compliance with court-mandated instream flows
- Improved irrigation water management
- Accelerate development of information for Tribes' water rights effort
- Calibration inputs for surface water allocation models and groundwater flow models

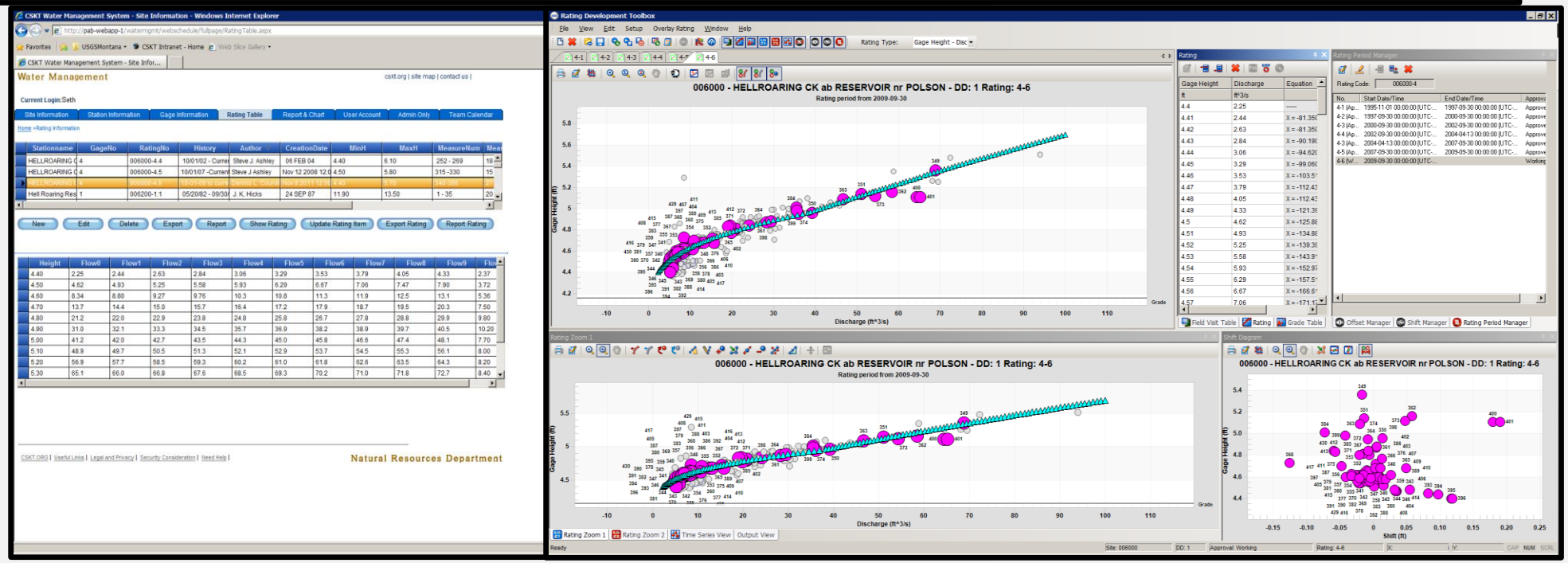


Water Measurement over Time - CSKT 1992 - 2014

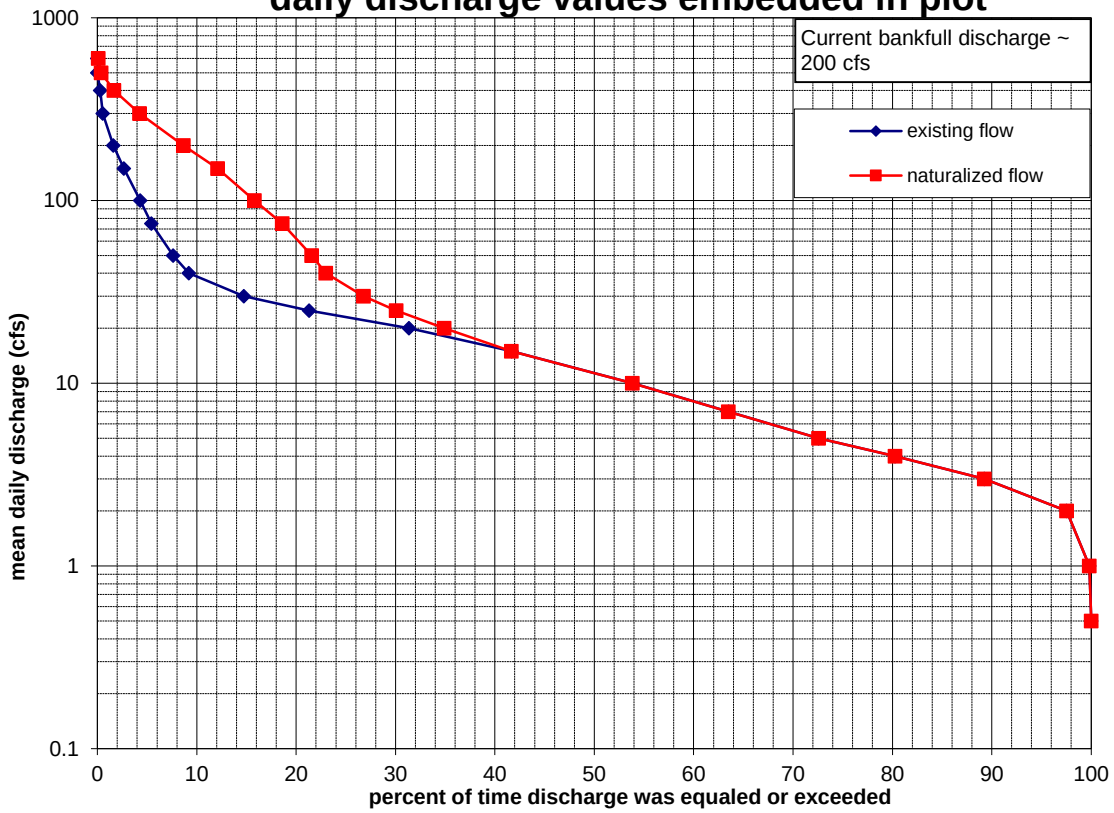
2000 – Migrate Fortran database to MS SQL database with web interface

- **At this point storing data for ~ 275 unique measurement locations, and over 850 individual ratings**
- **Preserve miscellaneous discharge measurements as locations**
- **Retain regression logic for rating table utilities**
- **Hot folders to pick up logger data**

Rating table legacy database. Same rating in Aquarius Time Series



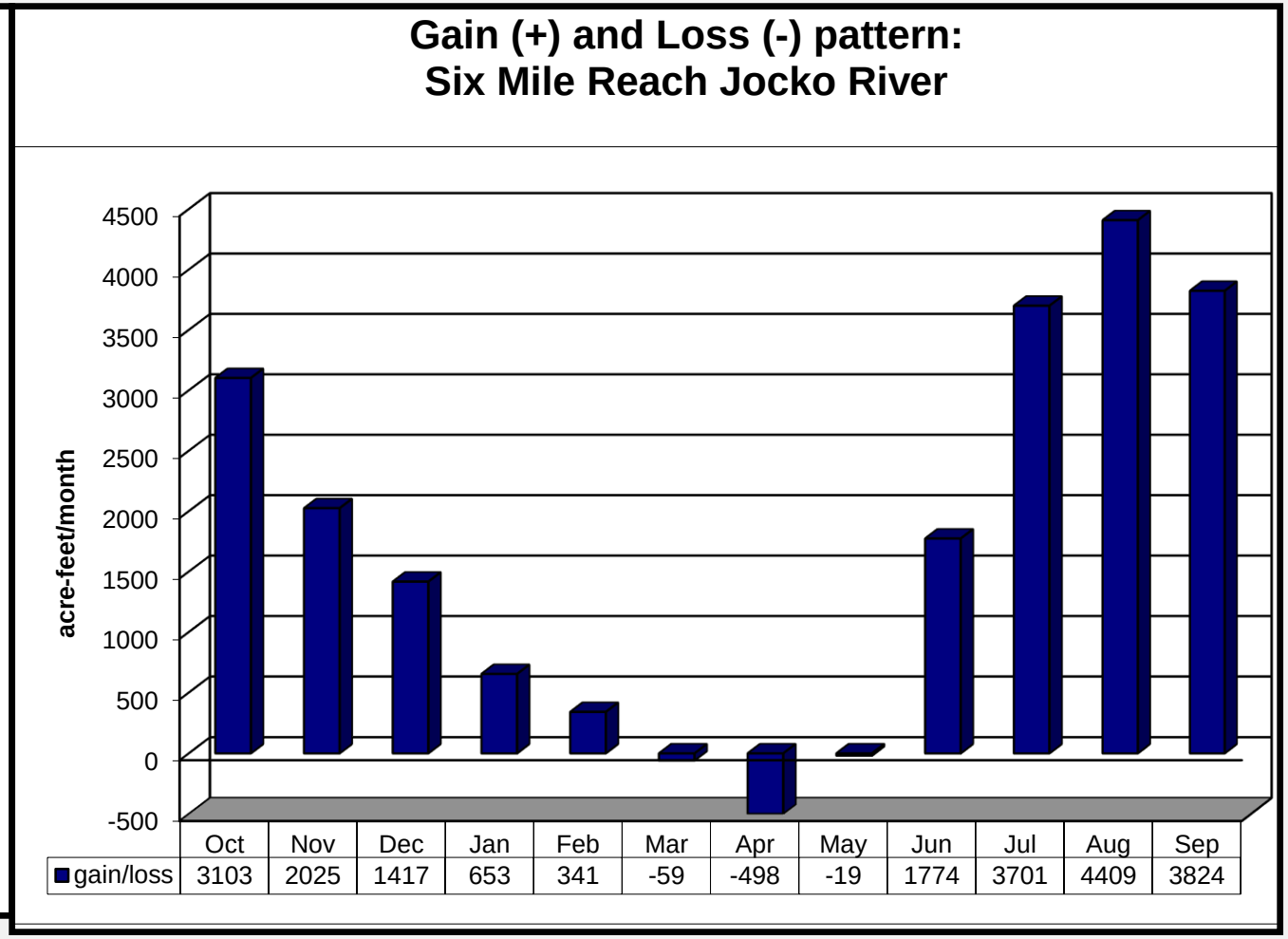
Sidebar – Some Data Applications



Flow Duration Curve – What should we base River Restoration Design on – Existing or Natural Flows

<u>Existing Flow: Bankfull discharge occurs ~ 7 days/year</u>

<u>Natural Flow: Bankfull discharge occurs ~ 31 days/year</u>



Surface Water – Groundwater Interactions based on Gage Mass Balance, validated with Synoptic Discharge Measurements

Fisheries Habitat, Model Calibration tool, …

Water Measurement over Time - CSKT 2014 - present

- Transition to Telemetry, requiring upgrade to field equipment
- Presently 82 real-time stations
- Natural streamflow, regulated streamflow, canal headworks, return flow/water quality stations, reservoirs

- 100% transition to acoustic doppler for discharge measurement

Added Technical Objective -

- Measurement to support implementation of Water Rights Compact
  - Consumptive and non-consumptive water rights described as Wet, Normal, and Dry year flows and volumes
  - Allows for Adaptive Management and some level of climate change resiliency
  - Water measurement key input for Adaptive Management and between-year and within-year water allocation

Simple Schematic of Instream Flow (non-consumptive) / Irrigation (consumptive) Water Right Implementation

Canal Heading Diversion/Decision Point

Fisheries Instream Flows – Minimum Enforceable dry year flow, normal year, wet year flow schedules

Water-Year type based on forecasting and natural flows

Irrigation River Diversion Allowances – Dry year, normal year, wet year diversion schedules

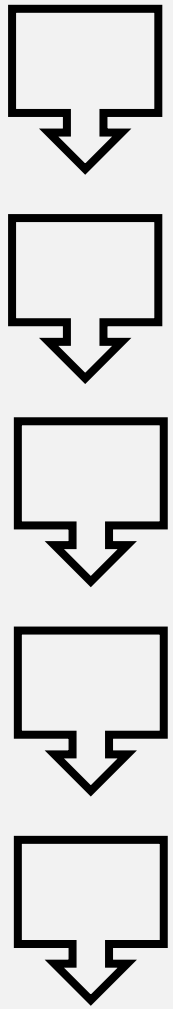
Instream Flow Right - varies through time to mimic natural hydrograph
Irrigation Right - seasonal volume, totalized through season

Aquarius Time Series Deployment 2016

Basic CSKT Steps for DB Migration / Deployment

- Vendor selection, including test deployments
- Structured Migration
- Validation of migration
- Learning and use of database, including updating rating curves
- AquariusWeb deployment
- Internal documentation and SOP's
- WebPortal enhancements to support user needs (anticipated)

Data Flow – *big change for us!*



Field Data Collection Platform *DCP*

GOES signal decoded in DCS Toolkit

DCS Toolkit passes data to AQDAS

AQDAS to Aquarius Time Series

Time Series to AquariusWeb

CSKT Adaptation to Aquarius Time Series/Telemetry

- Created new Job Position – Data Management Hydrologist responsible for - data flows from DCP to Web; In-House Training; required to maintain a set of gage locations
- Program staff - traditional skills are weighted towards field operations - growing our data manipulation / data management skills
  - Need to do this and maintain field expertise
- Data Management / Review / QA-QC has been very robust, but very traditional and paper intensive – maintain robust QA-QC, but work within framework of AQ Time Series
- Program has traditionally worked records at end of season. With Telemetry and AQ Time Series tools, need to maintain and grade records in near real-time
  - Due to highly contentious nature of water on Reservation, need to allow public access to data, while maintaining high quality standards for data publishing

Summary

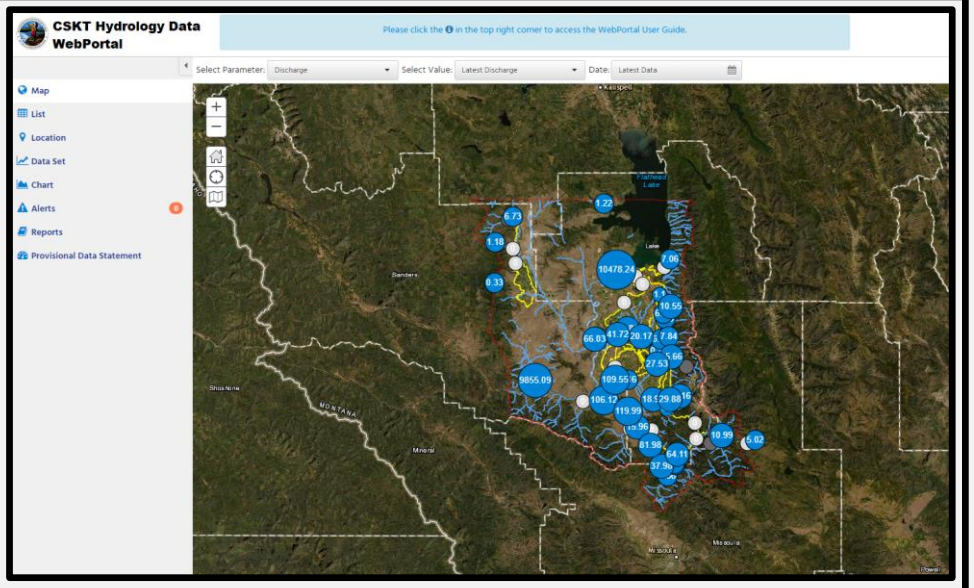
By the Numbers

- **Operate 80+ gages, approximately 50% larger canals**
- **Staffing – One Hydrologist (works ~ 50% on measurement tasks), Data Management Hydrologist, Chief of Field Operations, 4 Hydrographers**
  - **Staff operate about 15-18 gages, several other duties**
- **Found creative resources to fund launch of AQTS and telemetry network – not in regular budget**
- **Operate gage program on ~ 500k per year, Tribal funds, some federal funds, and now State funds**
- **Over $6,000 per year to operate a gage, canals lower cost**
- **Costs do not reflect start up of AQTS and electronics, just O&M**
- **Cost per year will grow. Program likely to shift to CSKT settlement**

Program Directions

- **Hydraulic structures at some canals**
- **Reservoir stage – 3 done, 10 more to go**
- **Staff mentoring and transition**
- **Take AQTS to SaaS (cloud)**
- **Improve Web interface**
- **Support settlement implementation**
- **Keep staff and program vibrant for next generation**

Public Access
https://www.csktwaterdata.org/AQWebPortal/



Questions

French Curves and Eraser Shavings to mouse clicks